Chapter

Asymmetric TVP-VAR Connectedness Approach: The Case of South Africa

Lethiwe Nzama, Thanda Sithole and Sezer Bozkus Kahyaoglu

Abstract

This chapter assesses connectedness of critical financial variables within the South African context. The key variables determining countries' international financial risk levels are the prices of their main export goods in the international markets. From this perspective, there is a connection between the prices of financialised commodities and precious metals in international markets, the exchange rates of the countries supplying these goods to the world economy and their risk indicators. As a result, a spill-over effect of financial risk increases the stress between the price movements in international markets, especially in countries whose national economy is based on the precious metals in question, and the risk indicators in international markets. From this point of view, the connection firstly between the gold prices (and secondly between platinum prices), which have an impact on the world economy, and the credit default swaps (CDSs), which show the country's risk level, and exchange rates of South Africa (RD) are examined. New econometric techniques are used for analysis based on the relevant literature. The empirical findings obtained from the study will be a source of information in the process of forming the economic policy of South Africa.

Keywords: gold and platinum prices, CDS, rand/dollar exchange rate, spillover, time-varying vector autoregressive (TVPVAR) model, dynamic connectedness, asymmetric connectedness, risk management, South Africa

1. Introduction

South Africa is a critical player in the global commodities. It is the largest producer (exporter) of global platinum [1]. In addition, South Africa is the eighth global producer of gold and, notably, the third largest in terms of global gold reserves, after Australia and Russia. Furthermore, the rand is one of the most traded emerging market currencies and, globally, among the top 20 [2, 3]. Understanding how it is integrated with commodities is crucial, considering the sovereign risk premium. Subsequently, this chapter studies the network connectedness of the dollar-denominated commodity (gold and platinum) prices, South Africa's rand exchange rate, and sovereign risk premium proxied by credit default swaps spread (CDS).

The connectedness of financial variables has increasingly become more critical for financial market participants and policymakers alike, especially after the 2007–2009 global financial crisis (GFC). Antonakakis et al. [4] echo this view and highlight that investigating the propagation of the financial crisis into the economy has been at the epicentre of academic research in recent years, especially in the aftermath of the GFC. Therefore, to provide insights into the financial market participants (and policymakers alike) interested in investing in South Africa, it is critical to understand the dynamic connectedness of commodities and currency accounting for the country's risk premium, as proposed here. Mensi et al. [5] argue that the growing cross-market information transmission in economic activities has amplified the contagion spillover and vulnerability of markets to external shocks. This provides context as to why studying the dynamic connectedness of financial networks is crucial.

To investigate how integrated our network is, we apply a Time-Varying Parameter–Vector Autoregressive (TVP-VAR) Connectedness Approach advanced by Antonakakis et al. [4] which was initially proposed by Diebold and Yilmaz [6]. This approach allows us to capture better the connectedness dynamics within the network of our selected financial variables. Several empirical studies have assessed the connectedness of commodities and exchange rate markets. A recent study by Mensi et al. [5], which extends from Antonakakis and Kizys [7], investigates volatility spillover, connectedness, and quantile dependence between precious metals and developed market currencies. Generally, their results reveal dynamic spillovers across precious metals and currencies and their respective connection with significant world events. However, their study does not include South Africa.

The most relevant recent study by Sayed and Charteris [3] investigates whether metals, grains, and energy commodities influence the South African rand and its volatility. They find a high degree of interconnectedness between the rand and commodities. Nevertheless, while their study is a good reference for our study, it does not account for the sovereign risk premium, which can provide further details in analysing the connectedness of the rand and commodities. In addition, our study is framed within an asymmetric time-varying setting, while their study uses a Dynamic Conditional Correlation-Generalised Autoregressive Conditional Heteroskedastic setting. Therefore, our study's contribution reflects both the time-varying connectedness approach and the inclusion of the CDS in the commodity-currency connectedness analysis in the case of South Africa.

The CDS spread can be used as a proxy for the sovereign credit risk profile, inferring those large spikes in CDS spread imply increased riskiness of sovereign assets, as investors demand high-risk premia to compensate for increased default risk [8]. Numerous studies have considered the connectedness of financial assets and CDS. Studies on the determinants of CDS have advanced two compelling reasons: firstly, financial integration and demand growth for sovereign CDS and secondly, investors' perception of higher credit risk and variability in emerging rather than developed markets [9]. Using Principal Component Analysis, de Boyri and Pavlova [9] find that global financial market factors are important drivers of sovereign CDS variability for the BRICS and MIST countries. Simonyan and Bayraktar [10] study the asymmetric dynamics in sovereign CDS pricing for a group of 11 emerging markets, including South Africa, and find some specific idiosyncratic and external factors (VIX and oil price) crucially affect CDS asymmetrically. Therefore, the CDS spread is crucial for financial market participants (and policymakers alike); so, we include it in our commodity-currency connectedness study for South Africa.

We focus on South Africa exclusively because of its global position within the African continent and its importance in the global commodities markets. In addition, we concur with Sayed and Charteris [3] that a single country study can provide great insights not identifiable in multiple country studies. Generally, we find a higher degree of interconnectedness within the network throughout the sample period. In addition, dynamic total connectedness is visibly responsive to some critical economic events, notably between 2014, 2016 and 2018.

The remainder of this chapter is organised in the following way: Section 2 provides a brief literature review on interconnectedness between financial variables, and network connectedness. Section 3 provides brief information about the data and details about the asymmetric TVP-VAR econometric model. Section 4 presents empirical findings, and Section 5 provides conclusions, as well as policy recommendations.

2. Literature review

In the literature, the real business cycle in the world has been analysed within the framework of world trade and world output. However, financial flows in the world economy have brought up the question of whether the global financial cycle is suitable for this, as well as analyses based on this real business cycle. In this regard, studies have begun to take into account the relationship between commodity prices, asset prices and financial risk indicators. In these studies, not only the real business cycle, but also the financial cycle and financial risk channels in this context were revealed. Thus, the sensitivity of the financial cycle to the relationship between commodity, asset and risk indicators is shown [11, 12]. In this study, the relations developed based on the aforementioned literature were analysed on a country basis within the framework of the asymmetric connectedness approach.

Various empirical publications have contributed to the investigation of global financial variable connectedness. Chatziantoniou et al. [13] apply the TVP-VAR Connectedness Approach to study interlinkages within a network of six major crude oil benchmarks[1]. Their study [13] found that the crude oil market exhibits a relatively high degree of co-movement with overall dynamic connectedness staying persistently above the 50% mark from May 14th, 1996, to December 3rd, 2020. Li et al. [14] use a time-varying connectedness approach to investigate the dynamics of return connectedness among crude oil, gold, and corn and stock, bond, and currency in China and the US. They find that, the total return of connectedness of the US commodity and financial assets are more robust than that of China and that both increased rapidly following the outbreak of the Covid-19 pandemic.

Yoon et al. [15] use the connectedness approach to investigate net return spillover between financial markets of stock, currency, and bond with oil and gold in the Asia Pacific Belt. Their research finds that the US stock market is the most critical contributor to the return spillover shock of the major stock markets in the Asia Pacific Belt, effectively reinforcing the importance of the US stock market. Adekoya and Oliyede [16] use TVP-VAR and causality-in-quantiles to investigate how the COVID-19 pandemic drives the spillover connectedness among US Dollar exchange rate, crude oil, gold, S&P 500, and Bitcoin. They find evidence of solid volatility across these markets

[1] Six major crude oil benchmarks are Brent, WTI, Dubai crude, Bonny Light, Tapis and OPEC basket reference.

and that gold, and the USD dollar are net receivers of shocks, while others are net transmitters. Many other empirical studies exist on the connectedness of commodities and financial markets. Among others, an interested researcher can also refer to [17–19]. For this brief chapter, we could not cover most empirical studies.

3. Data and methodology

3.1 Data

We use a daily dataset including credit default swaps (CDSs), exchange rates of South Africa (RD), gold prices, and platinum prices for the period of 05.01.2010–2017.06.2022. We transform the dataset into logarithmic return series before we start the empirical analysis stage. Hence, the descriptive statistic of our dataset is given in **Table 1**.

According to the kurtosis value in **Table 1**, which is the fourth moment, CDS has high variability, i.e., 54.68, compared to the kurtosis values of gold, platinum, and RD variables. This interpretation is valid for the entire data set since the other kurtosis values are all greater than three, i.e., 8.90; 9.42; 4.67, respectively.

Considering the skewness parameters in **Table 1**, which measure the asymmetry, the values of CDS and RD variables are greater than zero and are also positive. However, the asymmetry parameters of gold and platinum, i.e., the skewness values, reveal that the negative effects in these markets are more dominant than the positive effects. Notably, the skewness value of CDS, i.e., 2.28, appears as the financial risk indicator of South Africa, and the size of the asymmetric effect in the exchange rates seems to be an important indicator, as a country-specific condition. Therefore, the interconnectedness of these variables provides valuable information as an important financial risk indicator considering the South African economy. From this point of view, the results allow the analysis of the possible country risk according to the price movements in the international markets, while the feedback effects between the indicators of this can be seen. In this respect, the transition effect of the said negative effects from international markets to the country's financial risk indicator is calculated

	CDS	GOLD	PLA	RD
Mean	1.000222	1.000152	0.999849	1.000244
Median	1.000000	1.000374	1.000032	0.999829
Maximum	1.598863	1.049666	1.100920	1.064441
Minimum	0.728329	0.904879	0.863620	0.949187
Std. Dev.	0.030376	0.009636	0.013902	0.009682
Skewness	2.287893	−0.637971	−0.562645	0.300564
Kurtosis	54.68895	8.905508	9.424978	4.670437
Jarque-Bera	364522.3	4941.601	5759.749	426.6634
Probability	0.000000	0.000000	0.000000	0.000000

Table 1.
Descriptive statistics of dataset for South Africa – (2010–2022).

Variables	ADF-C	ADF-NONC	KPSS-C	KPSS-Lin-Cos
CDS	−16.623*	−0.0742	0.0205*	0.0211*
GOLD	−56.838*	−0.0147	0.1102*	0.1059*
PLA	−24.606*	−0.0498	0.0438*	0.0391*
RD	−56.783*	−0.0409	0.0619*	0.0391*
%1—	−3.432	−2.565	0.739	0.216
%5–	−2.862	−1.940	0.463	0.146

significant at 1% confidence level as I (0).

Table 2.
Unit-root test results of South African daily return series (2010–2022).

Variables	Q(20)	$Q^2(20)$	ARCH Effects
CDS	21.52***	65.974**	54.37**
GOLD	9.51	252.34**	141.68**
PLA	12.74	995.84**	569.09**
RD	15.743	389.02**	225.58**

****Significant at 5% chi-square distribution.*
***Significant at 1% chi-square distribution.*

Table 3.
ARCH effects on return series.

via CDS. The channel of transmission of this effect on the country's economy is through the exchange rates.

It is seen that the kurtosis values of all the variables are greater than three, that there is a significant risk in these markets and that the possible risk may have a high impact on the country's economy through the financial risk indicator channel. The presence of asymmetric effects and kurtosis values higher than three indicate that there may be a time-varying parameter relationship between these variables. Based on this assumption, we proceed to the next step to apply TVP-VAR Model.

All the return series are stationary, based on the unit-root test results given in **Table 2**. Along with the Augmented Dickey-Fuller-ADF test [20], the Kwiatkowski-Phillips-Schmidt-Shin-KPSS test was also applied [21]. Thus, the test result, which may be due to the insensitivity to the possible degree of integration being less than one, was verified with the KPSS test. Therefore, the data are considered stationary as I (0), since the test results support the results of the ADF test with a constant.

The ARCH test and Ljung Box Test, applied up to 20 lags to determine the presence of fat tails in the return series. Hence, as shown in **Table 3**, the ARCH effect is statistically significant and shows the presence of time-varying volatility[2] and Ljung Box test is used for analysing whether the specification is relevant to get "autocorrelation" and to capture the "time-varying volatility" in the return series.

[2] The ARCH test is a major instrument for determining the "conditional variance" based on the time dynamics of the second moments of the data. Hence, we could interpret a statistically significant ARCH test

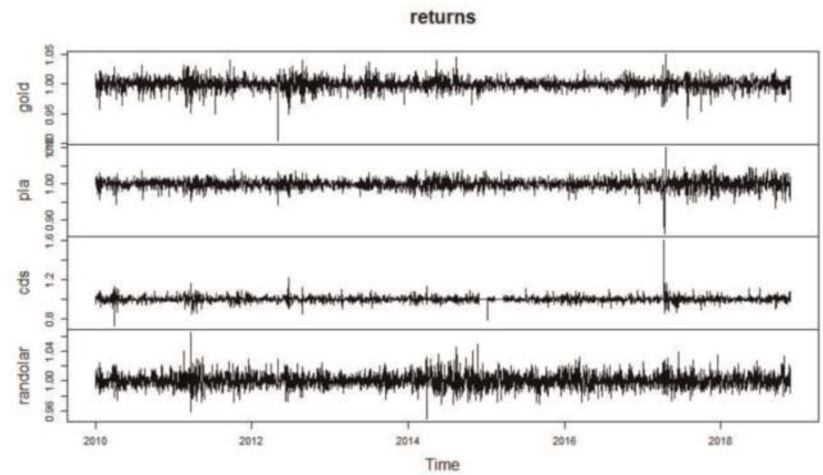

Figure 1.
Daily return series of gold, platinum, CDS, and RD (2010–2022).

After having the unit root test and ARCH test results, a daily percentage change of the dataset is prepared to determine absolute negative and positive return series. The dispersions of the daily change in return series are illustrated in **Figure 1**. In this respect, all the return series appear significantly skewed, and the JB test statistics support that these series are not normally distributed [22]. These initial descriptive findings of our return series support our method to apply TVP-VAR modelling with "time-varying variance-covariances".

3.2 Dynamic connectedness based time-varying vector autoregressive (TVPVAR) model

We use the "Time-Varying Parameter Vector-Autoregressive (TVP-VAR) Model" in our analysis because we aim to investigate the return-spillovers between the series. The brief literature review and the explanation of the TVP-VAR Model is given below.

This chapter applies the asymmetric dynamic interconnectedness approach to the South African financial time series data. This analysis is an extension of the empirical works of Diebold and Yılmaz [6–23]. These authors wrote the pioneering work regarding the development of "dynamic connectedness measures". In addition, we rely on the works of Antonakakis et al. [4] and, Kahyaoglu Bozkus and Kahyaoglu [24]. Antonakakis et al. [4] proposes a measure for dynamic connectedness, developed to evaluate time-varying parameter VAR models. In this way, they manage to cope with the drawbacks of the standard rolling-windows dynamic approach [25].

It is important to capture the asymmetries in the financial time analysis. In this respect, we calculate all the absolute returns both in positive and negative signs for our dataset. This calculation is essential for the TVP-VAR based connectedness approach [25]. In our case, we use TVP-VAR (1). This is suggested based on the Bayesian Information Criterion (BIC). Our approach is defined in Eqs. (1) and (2) as follows:

---

result as a representative of the time-varying volatility condition for the data. In addition, we could say that we have a volatility clustering with the existence of a fat-tailed distribution as a sign of mean reversion tendency in the return series. On the other hand, it should be noted that the existence of a significant excess

$$z_t = B_t z_{t-1} + u_t \qquad u_t \sim N\left(0, \sum\nolimits_t\right) \tag{1}$$

$$vec(B_t) = vec(B_{t-1}) + v_t \qquad v_t \sim N(0, R_t) \tag{2}$$

Where:

z_t and z_{t-1}	$k \times 1$ vector in t, $t-1$ period.
u_t	the error term
B_t and $\sum_t$	$k \times k$ matrices with the time-varying VAR coefficients and the time-varying variance-covariances
$vec(B_t)$	$k^2 \times 1$ vector
v_t	$k^2 \times 1$ vector
R_t	$k^2 \times k^2$ matrix

According to the "Wold Representation Theorem" introduced by Pesaran and Shin [26], it is necessary to transform the estimated TVP-VAR model into its TVP-VMA process by using Eq. (3):

$$z_t = \sum_{i=1}^{p} B_{it} z_{t-i} + u_t = \sum_{j=0}^{\infty} A_{jt} u_{t-j} \tag{3}$$

The index for "pairwise directional connectedness", "total directional connectedness", "NET total directional connectedness" and "total connectedness index (TCI)" from j to i are formulated and obtained via R program based on the recent work of [27]. These authors define "influence variable (H) as forecast horizon" as follows:

$$\tilde{\varphi}^g_{ij,t}(H) = \frac{\tilde{\varphi}^g_{ij,t}(H)}{\sum_{j=1}^{k} \varnothing^g_{ij,t}(H)} \tag{4}$$

In this respect, we begin our analysis by determining the average connectedness measure, i.e., without considering asymmetry. It should be noted that all figures relate concurrently to both negative and positive returns and the symmetric connectedness measures. In other words, "off-diagonal factors" in the figures indicate the interaction between the variables in the system. On the other hand, the "elements in the main diagonal" match to "idiosyncratic shocks", namely, "own-innovations" for the series. The process is followed by applying Eq. (4) to calculate different cases based on the work of Kahyaoglu, Bozkus and Kahyaoglu [24] such that:

1. *Total directional connectedness TO others*: where variable i spreads its shock wave to all additional variables j, called total directional connectedness TO others.

2. *Total directional connectedness FROM others:* where the shock wave variable i gets from variables j.

---

kurtosis (i.e., excess kurtosis >0) is not representative of time-varying volatility. Still, the inverse of this hypothesis is true.

3. *NET total directional connectedness*: where we calculate by deducting "the total directional connectedness TO others" from" the total directional connectedness FROM others." This indicates the "influence variable" *i* has on the examined system.

4. *Total connectedness index (TCI)*: This index is used as the final stage to see the whole market, i.e., the market interconnectedness.

5. *The pairwise connectedness index (PCI)*: TCI is decomposed to obtain the interconnectedness between two variables, *i* and *j*. According to Gabauer [27], PCI metrics range between [0, 1] and this shows the "degree of pairwise interconnectedness".

4. Empirical results analysis

We studied the effects of the daily changes in the prices of gold and platinum, two important export items from South Africa, on the country's financial risk indicator (CDS) and the exchange rates (RD). Our empirical findings from the asymmetric TVP-VAR Model connectedness analysis are as follows:

The empirical results of the TVP-VAR Model are obtained based on South Africa's return series for the examined period, and they are given in **Table 4**, and **Figure 2**, **Figure 3**, **Figure 4**, and **Figure 5**, respectively. In general, we monitor that the connectedness level in the network reaches high values between 2014 and 2016 and during early 2018 (**Figure 2**). Considering **Figure 2**, 2014, 2016 and 2018 seem to be prominent as the periods of shocks in South Africa. The country-specific events that occurred during these periods, triggering these effects, are summarised in **Table 5**.

After we make the prediction error variance decomposition, two critical pieces of information emerge. These are called variance shares, which originate from "internal shocks" and "external shocks". External shocks are also called "spillovers" in the literature. The connectedness results in **Table 4** constitute essential details, where all the relationships in the system can be defined to understand the **"**big picture**"**, i.e., the South African case.

In this model, for each variable, Y-return, p-positive, and n-negative returns are shown at **Table 4**. The difference of negative and positive returns of the variables means the divergence of positive and negative effects in this model. Therefore, these effects are defined as "asymmetric" effects.

Notably, there is a spillover from the gold market to the platinum market. The value of (11.16) can be interpreted as a measure of this effect. In general, the positive and negative effects in the gold market do not have an asymmetrical effect on the gold market. This is underpinned by the findings that the gold's positive and negative returns are effectively at similar rates, i.e., gold. Yp (12.65) and gold. Yn (12.22) values are close to each other showing this fact. There is a similar situation occurring from the platinum market to the gold market. However, the gold market appears to be a higher shock receiver than the platinum market because the spread from pla.Y to gold. Y is (13.11), while the reverse spillover is at the level of (11.16).

The cds.Y variables receive the biggest shock from themselves. However, there is a difference between the positive and negative effects, considering the financial markets' perspectives of the South African economy. The positive and negative difference here is that the negative shock of cds.Y causes a faster increase than positive shocks, reflecting that the increase in CDSs will have a negative effect on the economy. Since

Variable	gold.Y	pla.Y	cds.Y	rd.Y	gold.Yp	pla.Yp	cds.Yp	rd.Yp	gold.Yn	pla.Yn	cds.Yn	rd.Yn	FROM
gold.Y	29.14	13.11	1.88	3.14	14.14	8.51	1.65	2.69	13.66	7.72	1.70	2.66	**70.86**
pla.Y	11.16	25.29	3.72	4.53	6.28	15.15	3.24	3.79	6.26	13.57	3.27	3.75	**74.71**
cds.Y	1.76	4.24	29.30	10.11	2.37	2.75	15.68	7.21	2.62	2.23	14.64	7.08	**70.70**
rd.Y	2.84	4.74	7.93	26.25	3.17	3.34	5.92	16.91	3.38	3.01	5.88	16.63	**73.75**
gold.Yp	12.65	6.60	2.27	3.34	26.33	5.88	2.19	3.31	26.22	5.66	2.24	3.30	**73.67**
pla.Yp	7.23	15.31	2.49	3.36	5.89	25.09	2.28	3.08	5.89	23.95	2.38	3.06	**74.91**
cds.Yp	1.54	3.61	14.56	6.69	2.45	2.63	26.72	6.23	2.73	2.08	24.61	6.13	**73.28**
rd.Yp	2.13	3.69	5.63	16.16	2.89	2.79	5.24	25.32	3.11	2.40	5.32	25.31	**74.68**
gold.Yn	12.22	6.52	2.41	3.44	26.12	5.81	2.37	3.41	26.32	5.58	2.41	3.39	**73.68**
pla.Yn	7.13	14.34	2.23	3.36	6.04	24.98	1.99	2.99	6.01	25.85	2.09	2.98	**74.15**
cds.Yn	1.60	3.65	13.71	6.62	2.54	2.74	24.71	6.27	2.82	2.18	27.00	6.18	**73.00**
rd.Yn	2.13	3.67	5.57	16.00	2.90	2.78	5.19	25.48	3.10	2.40	5.28	25.50	**74.50**
TO	**62.39**	**79.48**	**62.39**	**76.76**	**74.81**	**77.37**	**70.47**	**81.38**	**75.80**	**70.78**	**69.84**	**80.45**	**881.91**
Inc.Own	91.53	104.77	91.69	103.01	101.13	102.46	97.18	106.70	102.12	96.62	96.83	105.95	cTCI/TCI
NET	**−8.47**	**4.77**	**−8.31**	**3.01**	**1.13**	**2.46**	**−2.82**	**6.70**	**2.12**	**−3.38**	**−3.17**	**5.95**	80.17/73.49
NPT	**0.00**	**9.00**	**2.00**	**8.00**	**6.00**	**5.00**	**3.00**	**11.00**	**7.00**	**3.00**	**2.00**	**10.00**	

gold.Y-Return of Gold Series; pla.Y-Return of platinum series; cds.Y-Return of CDS; rd.Y-Return of RD series. gold.Yn-Negative Return of Gold Series; pla.Yn- Negative Return of platinum series; cds.Yn- Negative Return of CDS; rd.Yn- Negative Return of RD series gold.Yp-Positive Return of Gold Series; pla.Yp- Positive Return of platinum series; cds.Yp- Positive Return of CDS; rd.Yp- Positive Return of RD series, Inc.Own: Including own contributions, TCI:Total Connectedness Index, NET:Net Total Connectedness, NPT: Net Pairwise Total Connectedness.

Table 4.
Empirical findings of asymmetric connectedness analysis with TVP-VAR approach.

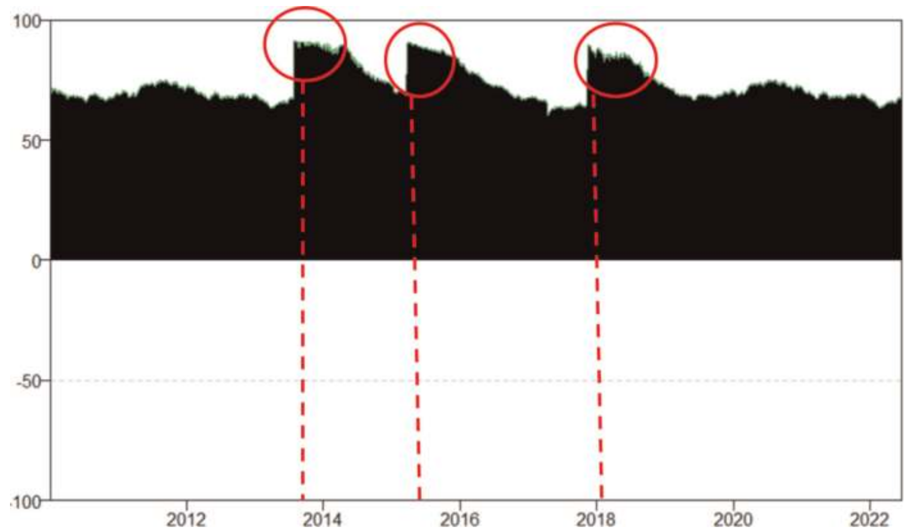

Figure 2.
Asymmetry of dynamic total connectedness. Note: Results are obtained from TVP-VAR model. This model is established with the lag length of order one (BIC). We use a 20-step-ahead "generalised forecast error variance decomposition".

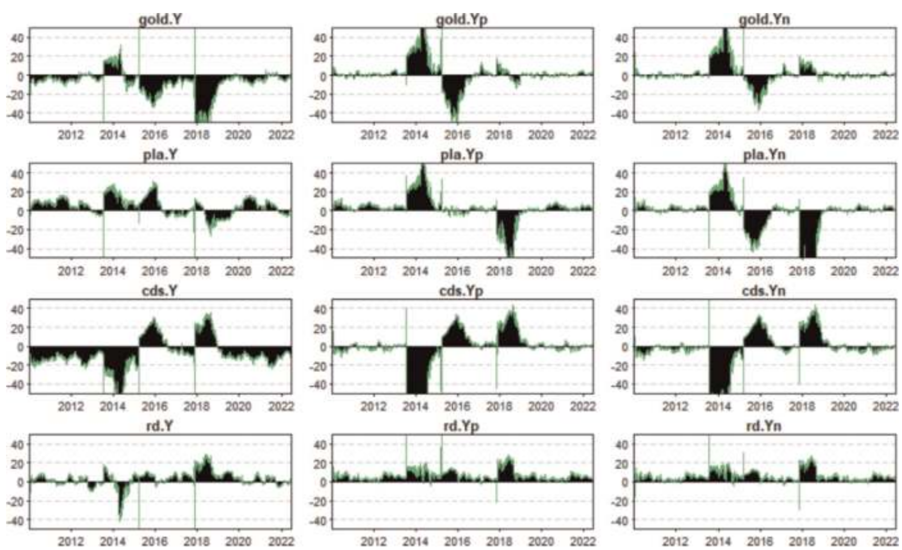

Figure 3.
Dynamic net total directional connectedness.

cds.Yp expresses the positive shock increase direction in our CDS variable, it expresses the negative impact on the economy. From this point of view, the impact of the shock in international financial markets on South Africa is asymmetrical in both positive and negative directions. In this context, it is possible to say that the general effect of this shock on the country's economy also shows an asymmetrical spillover on the exchange rates. However, this asymmetric effect does not differ much in terms of positive and negative effects on exchange rates. This is related to the fact that the shock of CDS (cds.Y) from exchange rate (rd.Y) is (10.11), which is greater than the shock of exchange rates (rd.Y) from CDS (cds.Y). For this reason, the effects of a shock, whether from exchange rates or CDSs, on CDSs after a period will be greater anyway.

Figure 4.
Dynamic net pairwise directional connectedness. Notes: Results are obtained from TVP-VAR model. This model is established with the lag length of order one (BIC). We use a 20-step-ahead "generalised forecast error variance decomposition". Black area shows the symmetric pairwise connectedness. Green and red lines indicate the "positive and negative pairwise connectedness measures", respectively.

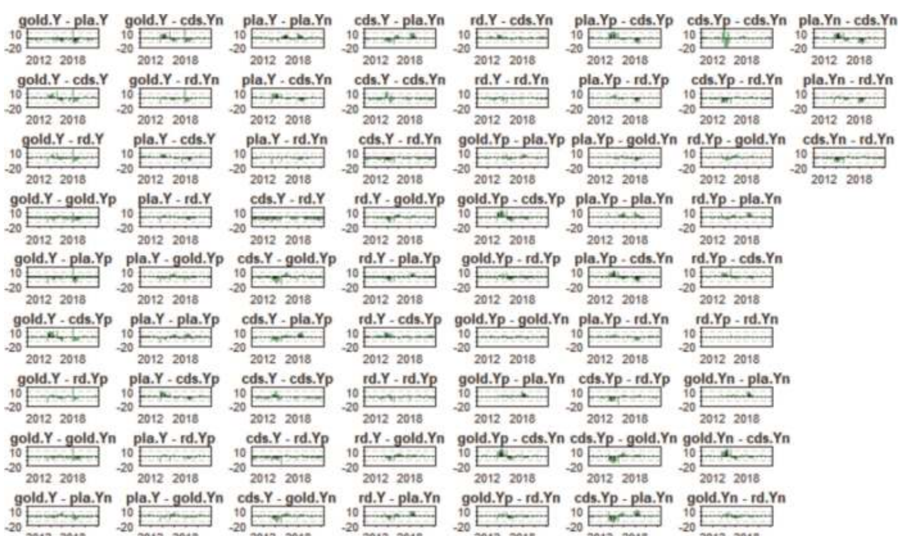

Figure 5.
Net pairwise directional connectedness.

The important point here is that there is a difference between the shock value of each variable from the total connectedness and the total shock of each positive and negative shock. Suppose this situation is considered as a difference in the spillover effects from the total connectedness to the positive and negative, and from the positive and negative to the total connectedness. In that case, it is seen that there is a significant asymmetric effect due to the interaction between the exchange rates and CDS in South Africa. Considering the openness of the South African economy, novel monetary policy implementations are needed to manage this asymmetry. Within the framework of the knowledge that the CDSs are the main risk indicator in international markets, public finance should also be considered in the new regulation process in South Africa.

SA Specific Events	Negative	Positive
2018	Land reform constitution change announcement - Heightening policy uncertainty	Moody's affirmed SA credit rating
		Tito Mboweni appointed as Finance Minister
		Moody's upgrade SA outlook to stable
		Nhlanhla Nene appointed as Finance Minister
		Cyril Ramaphosa appointed as President
		Jacob Zuma resigns
2017	Heightened policy uncertainty around the Third Mining Charter release	Cyril Ramaphosa appointed as ANC president (54th Conference)
2016	Domestic drought, above-target inflation outcomes	
	SA lose investment grade (for foreign currency debt) with two of the three major rating agencies	
2015	"Nene-gate": Minister of Finance Nhlanhla Nene replaced by a relatively unknown Desmond van Rooyen	Four days later Pravin Gordon appointed as Finance Minister
	Electricity load shedding	
	Domestic drought, above-target inflation outcomes	
2014	African Bank experienced liquidity stress, generating risk across financial markets and risk of contagion	
	Widening current account deficit	

Source: Chatterjee and Sing [28], The World Bank [29], Authors.

Table 5.
Summary of negative and positive events in South Africa - 2014–2018.

Even if the values in **Table 4** seem to be relatively close to each other when making interpretations, it should be considered that they are all obtained from daily data. The fact that the total connectivity among the data we have analysed is 73%, provides important information. The empirical findings of the study provide valuable information for the establishment of macro-financial stability policies and give reliable information about the future risk directions in the economy. This can be considered, especially regarding South Africa's presence in international financial markets with the country's main export items, which are the financialised commodities.

5. Conclusion

The gold, platinum, exchange rates, and CDS data of South Africa we have investigated can be seen as an early warning risk indicator for the economy. In this context, based on the TVP-VAR model, findings obtained for these indicators, expresses the asymmetric time-varying connectedness of the country's economy to international financial markets.

In general, gold and CDSs are the ones that give shocks to the system, while platinum and the exchange rates are the ones that take the shocks. When the positive and negative effects of each of the variables are examined, it is clearly seen that there is a difference in whether the system is shocked or not.

In the case of gold and the exchange rates, which are negative for the country, these variables are also shock receivers. This means that the positive and negative variables in question reveal a trend in the same direction for the country. However, the negative effects of CDSs and platinum, that is, an increase in CDSs, which is negative for the country, and changes in platinum prices are shock generating for the country.

An important point to note about CDSs is that shocks originating from the agricultural sector, which are not included in our model, but which are especially important for most countries, should also be taken into account. Assuming that the CDS data will be affected by such shocks, we can say that this connectivity may be effective in the country's economy due to its high value.

Net effects show asymmetric effects due to positive and negative interactions. The important finding here is that it should be emphasised that our model is valid with a time-varying approach. This necessitates institutional policies that will synchronise the reflections of these markets from an economic point of view. Considering that the important source of demand in the precious metals sector is affected by the Chinese economy, it can be stated that the growth trend of that economy should also be closely monitored.

Acknowledgements

We would like to thank the University of Johannesburg for funding the publication fees for our study.

We would like to also thank Prof. David Gabauer for his kind assistance by providing R codes.

Conflict of interest

"The authors declare no conflict of interest."

Author details

Lethiwe Nzama[1*], Thanda Sithole[2] and Sezer Bozkus Kahyaoglu[3,4,5]

1 University of Johannesburg, College of Business and Economics School of Accounting, Department of Commercial Accounting, Rossmore, Johannesburg, South Africa

2 Senior Economist, Johannesburg, South Africa

3 Izmir Bakircay University, Izmir, Turkiye

4 University of Johannesburg, Johannesburg, South Africa

5 Manas University, Bishkek, Kyrgyz Republic

*Address all correspondence to: lethiwen@uj.ac.za

References

[1] US Geological Survey. Mineral commodity summary. US Geological Survey; 2022. DOI: 10.3133/msc2022

[2] Bank for International Settlement. BIS Triennial central bank survey; 2019. Available from: https://www.bis.org/statistics/rpfx19_fx.htm

[3] Sayed A, Charteris A. Is the rand a commodity currency? A volatility spillover analysis. 2022. DOI: 10.1080/10293523.2022.2090079

[4] Antonakakis N, Chatziantoniou I, Gabauer D. Refined measures of dynamic connectedness based on time-varying parameter vector autoregressions. Journal of Risk and Financial Management. 2020;**13**(4):84. DOI: 10.3390/jrfm13040084

[5] Mensi W, Ali SR, Vinh VX, Kang S. Multiple dependence, spillovers, and connectedness between precious metals and currency markets: A safe haven analysis. SSRN. 2022. DOI: 10.2139/ssrn.4016986

[6] Diebold FX, Yılmaz K. On the network topology of variance decompositions: Measuring the connectedness of financial firms. Journal of Econometrics. 2014;**182**(1):119-134. DOI: 10.1016/j.jeconom.2014.04.012

[7] Antonakakis N, Kizys R. Dynamic spillovers between commodity and currency markets. International Review of Financial Analysis. 2015;**41**:303-319. DOI: 10.1016/j.irfa.2015.01.016

[8] Rikhotso PM, Simo-Kengne BD. Dependence structures between sovereign credit default swaps and global risk factors in BRICS countries. Risk and Financial Management. 2022:15-109. DOI: 10.3390/jrfm15030109

[9] de Boyrie ME, Pavlova I. Dynamic interdependence of sovereign credit default swaps in BRICS and MIST countries. Applied Economics. 2016;**48**: 563-575. DOI: 10.1080/00036846.2015.1083089

[10] Simonyan S, Bayraktar S. Asymmetric dynamics in sovereign credit defaults swaps pricing: Evidence from emerging countries. International Journal of Emerging Markets. 2022. Available from. DOI: https://www.emerald.com/insight/1746-8809.htm

[11] Miranda-Agrippino Silvia, Hélène Rey, Chapter 1 - The global financial cycle. Gita Gopinath, Elhanan Helpman, Kenneth Rogoff. editors. In: Handbook of International Economics, Vol. 6. Elsevier; 2022. pp. 1-43. ISSN: 1573-4404, ISBN: 9780323957724. DOI: 10.1016/bs.hesint.2022.02.008

[12] Stéphane Z. New evidence on international risk-sharing in the economic community of West African States (ECOWAS). International Economics. 2021;165:121-139. ISSN: 2110-7017. DOI: 10.1016/j.inteco.2020.11.003

[13] Chatziantoniou I, Gabauer D, Gupta R. Integration and risk transmission in the market for crude oil: A time-varying parameter frequency connectedness approach. Working Paper, June 2021-47. University of Pretoria, Department of Economics, Pretoria, Gauteng, South Africa. Available from: https://www.up.ac.za/media/shared/61/WP/wp_2021_47.zp209709.pdf

[14] Li X, Li B, Wei G, Bai L, Wei Y, Liang C. Return connectedness among commodity and financial assets during

the COVID-19 pandemic: Evidence from China and the US. Resources Policy. 2021;**73**. DOI: 10.1016/j.resourpol.2021.102166

[15] Yoon SM, Mamun M, Uddin GS, Kang SH. Network connectedness and net spillover between financial and commodity markets. The North American Journal of Economics and Finance. 2019;**48**:801-818. DOI: 10.1016/j.najef.2018.08.012

[16] Adekoya OB, Oliyede JA. How COVID-19 drives connectedness among commodity and financial markets: Evidence from TVP-VAR and causality-in-quantiles technique. Resources Policy. 2021;**70**. DOI: 10.1016/j.resourpol.2020.101898

[17] Mensi W, Vo XV, Kang SH. Time and frequency connectedness and network across the precious metal and stock markets: Evidence from top precious metal importers and exporters. Resources Policy. 2021;**72**. DOI: 10.1016/j.resourpol.2021.102054

[18] Bouri E, Cepni O, Gabauer D, Gupta R. Return connectedness across asset classes around the COVID-19 outbreak. International Review of Financial Analysis. 2021;**73**. DOI: 10.1016/j.irfa.2020.101646

[19] Zhang D, Broadstock DC. Global financial crisis and rising connectedness in the international commodity markets. International Review of Financial Analysis. 2020;**68**. DOI: 10.1016/j.irfa.2018.08.003

[20] Dickey D, Fuller W. Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association. 1979;**74**:427-431. DOI: 10.1080/01621459.1979.10482531

[21] Kwiatkowski D, Phillips PCB, Schmidt P, Shin Y. Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics. 1992;**54**:159-178. DOI: 10.1016/0304-4076(92)90104-Y

[22] Jarque CM, Bera AK. Efficient tests for normality, homoscedasticity and serial independence of regression residuals. Economics Letters. 1980;**6**(3):255-259. DOI: 10.1016/0165-1765(80)90024-5

[23] Diebold FX, Yılmaz K. Better to give than to receive: Predictive directional measurement of volatility spillovers. International Journal of Forecasting. 2012;**28**:57-66. DOI: 10.1016/j.ijforecast.2011.02.006

[24] Kahyaoglu Bozkus S, Kahyaoglu H. Financial connectedness of energy and commodity markets and systemic risk. In: Hacioglu U, Aksoy T, editors. Financial Ecosystem and Strategy in the Digital Era. Contributions to Finance and Accounting. Springer, 2021. Champions. DOI: 10.1007/978-3-030-72624-9_5

[25] Adekoya OB, Akinseye A, Antonakakis N, Chatziantoniou I, Gabauer D, Oliyide JA. Crude oil and Islamic sectoral stocks: Asymmetric connectedness and investment strategies. 2021. DOI: 10.1016/j.resourpol.2022.102877

[26] Pesaran MH and Shin Y. An autoregressive distributed-lag modelling approach to cointegration analysis. In: Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium. Vol. 31. 1998. pp. 371-413. DOI: 10.1017/CCOL0521633230.011

[27] Gabauer D. Dynamic measures of asymmetric & pairwise spillovers within an optimal currency area: Evidence from

the ERM I System. Journal of Multinational Financial Management. 2021:100680. DOI: 10.1016/j.mulfin.2021.100680

[28] Chatterjee S, Sing M. Measuring Systemic Risk in South African Banks. Working Papers 11004, South African Reserve Bank. 2021

[29] The World Bank. South Africa Economic Update; Jobs and Inequality. The World Bank. 2018. Available from: https://thedocs.worldbank.org/en/doc/798731523331698204-0010022018/original/SouthAfricaEconomicUpdateApril2018.pdf